Association between smoking and tuberculosis infection: a population survey in a high tuberculosis incidence area

S den Boon, S W P van Lill, M W Borgdorff, S Verver, E D Bateman, C J Lombard, D A Enarson, N Beyers

Background: Associations between smoking and tuberculosis disease including death from tuberculosis have been reported, but there are few reports on the influence of smoking on the risk of developing Mycobacterium tuberculosis infection. The aim of this study was to determine the association between smoking and M tuberculosis infection.

Methods: In a cross sectional population survey, data on smoking and tuberculin skin test (TST) results of 2401 adults aged ≥15 years were compared.

Results: A total of 1832 (76%) subjects had a positive TST (≥10 mm induration). Of 1309 current smokers or ex-smokers, 1070 (82%) had a positive TST. This was significantly higher than for never smokers (unadjusted OR 1.99, 95% confidence interval (CI) 1.62 to 2.45). A positive relationship with pack-years was observed, with those smoking more than 15 pack-years having the highest risk (adjusted OR 1.90, 95% CI 1.28 to 2.81).

Conclusion: Smoking may increase the risk of M tuberculosis infection.

RESULTS

Of 3512 adults who completed the questionnaire, a TST result was recorded in 2443 (70%). Data on smoking habits were incomplete in 42 individuals so analyses were performed on 2401. Compared with subjects excluded from the analyses, those included were less often male (unadjusted OR 0.57, 95% CI 0.49 to 0.65), less often current or ex-smokers (unadjusted OR 0.82, 95% CI 0.70 to 0.94), and fewer had an income above 2000 Rand (300 US$) (unadjusted OR 0.62, 95% CI 0.51 to 0.76).

Of the 2401 adults analysed, 1832 (76%) had a positive TST and 1309 (55%) were current or ex-smokers; 82% (n = 1070) of the 1309 current or ex-smokers had a positive TST compared with 70% (n = 762) of the 1092 never smokers (unadjusted OR 1.99, 95% CI 1.62 to 2.43). Men were more likely to have a positive TST than women (unadjusted OR 1.34, 95% CI 1.08 to 1.65; table 1). A positive TST was more common in the 25–44 year age group than in other age groups. The proportion of individuals with a positive TST increased with income, but not with education level or BMI (data not shown).

In the multiple logistic regression analyses, income and sex did not confound the association between smoking and infection. However, as sex was associated with smoking and with having a positive TST, it was retained in the model. The

TUBERCULOSIS
association between infection and pack-years smoked was not significantly different for the different age and sex strata. After adjusting for age and sex, there was a significant association between smoking and a positive TST (adjusted OR 1.77, 95% CI 1.41 to 2.21). The probability of a positive TST seemed to increase slightly with the number of pack-years smoked, although the differences between the different pack-year categories were not significant (table 1).

**DISCUSSION**

This study shows that current or ex-smokers had a higher prevalence of *M tuberculosis* infection than never smokers and that there was a slightly higher risk of infection for those who smoked more than 15 pack-years than for those who smoked less, although this was not significant. This suggests that the increased risk of disease and death from tuberculosis among smokers may be, at least in part, to an increased risk of smokers becoming infected with *M tuberculosis*.

An unexpected finding was the positive association between a positive TST and income. It should be noted, however, that the mean incomes in the study area are low, and that the categorisation threshold used in the analyses identifies only the poorest in the community. Nevertheless, the reason for their lower TST rates requires further study, including the possibility of lower risk of exposure through fewer social contacts.

Our study confirms previous studies that showed an association between smoking and tuberculosis infection in at risk groups. For example, in an immigrant population Plant et al reported a higher risk of infection among smokers which increased with duration of smoking. In contrast to previous studies investigating specific high risk groups, the current study is the first to investigate the association between smoking and tuberculosis infection in a cross-sectional population survey in a high incidence community.

The reason for the increased risk of infection in smokers is unclear, but may be explained by the effects of smoking on pulmonary host defences. Smoking has been shown to reduce natural killer cytotoxic activity, to suppress T cell function in both lung and blood, to impair mucociliary clearance of particles, and to increase numbers of alveolar macrophages in the lower respiratory tract. Cells of the macrophage-phagocytic group influence immediate or innate immunity through their handling and elimination of mycobacteria, and products of cigarette smoke may therefore favour persistence and/or replication of ingested mycobacteria by impairing the macrophage or dendritic cell function.

To take possible sources of bias into account we have considered the following. Men and persons in the highest income category are under-represented, but this is unlikely to be of significance as neither sex nor income was a confounder for the association between smoking and positive TST. Smokers and ex-smokers were also slightly under-represented but still comprised 55% of the sample, and we can see no reason to assume that the smokers who had undergone a TST might be different from those who had not. A weakness of the study is that we did not test the HIV status.

**Table 1** Risk factors for *M tuberculosis* infection

<table>
<thead>
<tr>
<th>Smoking (pack-years)</th>
<th>TST &gt;10 mm</th>
<th>Total</th>
<th>% TST &gt;10 mm</th>
<th>Odds ratio Unadjusted (95% CI)</th>
<th>Odds ratio Adjusted* (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never smoked</td>
<td>769</td>
<td>1102</td>
<td>70</td>
<td>1.86 (1.42 to 2.43)</td>
<td>1.77 (1.33 to 2.35)</td>
</tr>
<tr>
<td>&lt;5</td>
<td>443</td>
<td>550</td>
<td>81</td>
<td>2.39 (1.74 to 3.29)</td>
<td>1.77 (1.25 to 2.50)</td>
</tr>
<tr>
<td>5-15</td>
<td>343</td>
<td>407</td>
<td>84</td>
<td>2.00 (1.40 to 2.84)</td>
<td>1.90 (1.28 to 2.81)</td>
</tr>
<tr>
<td>&gt;15</td>
<td>236</td>
<td>288</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>41</td>
<td>54</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1100</td>
<td>1477</td>
<td>74</td>
<td>1.34 (1.08 to 1.65)</td>
<td>1.24 (0.99 to 1.56)</td>
</tr>
<tr>
<td>Male</td>
<td>731</td>
<td>923</td>
<td>79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>1</td>
<td>1</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-24</td>
<td>432</td>
<td>651</td>
<td>66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-34</td>
<td>444</td>
<td>498</td>
<td>89</td>
<td>4.47 (3.14 to 6.37)</td>
<td>4.30 (3.00 to 6.17)</td>
</tr>
<tr>
<td>35-44</td>
<td>412</td>
<td>484</td>
<td>85</td>
<td>3.16 (2.28 to 4.37)</td>
<td>2.82 (2.00 to 3.99)</td>
</tr>
<tr>
<td>45-54</td>
<td>263</td>
<td>330</td>
<td>80</td>
<td>2.11 (1.50 to 2.97)</td>
<td>1.94 (1.35 to 2.85)</td>
</tr>
<tr>
<td>&gt;55</td>
<td>264</td>
<td>408</td>
<td>65</td>
<td>0.88 (0.66 to 1.18)</td>
<td>0.88 (0.64 to 1.22)</td>
</tr>
<tr>
<td>Unknown</td>
<td>17</td>
<td>30</td>
<td>57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income (Rands)†</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;500</td>
<td>804</td>
<td>1088</td>
<td>74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500-1999</td>
<td>685</td>
<td>893</td>
<td>77</td>
<td>1.18 (0.94 to 1.48)</td>
<td></td>
</tr>
<tr>
<td>≥2000</td>
<td>315</td>
<td>381</td>
<td>83</td>
<td>1.93 (1.38 to 2.68)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>28</td>
<td>39</td>
<td>72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1832</td>
<td>2401</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Adjusted for pack-years, age, sex, and taking into account possible clustering at address level.
†6.50 = US$1.00.
of participants and were therefore not able to correct for HIV status. Confounding factors that were taken into consideration were individual monthly income, BMI, and education level. However, we cannot entirely discount the possibility that socioeconomic and behavioural differences other than smoking may have affected the relationship between smoking and tuberculosis infection.

We conclude that smoking may increase the risk of *M. tuberculosis* infection. We propose that further studies be conducted to investigate this association and to establish whether smoking reduction strategies contribute to tuberculosis control.

**ACKNOWLEDGEMENTS**

The authors thank Dr Ivan Toms, Director of Health, City of Cape Town for permission to work in the community, Neil White and Elvis Iruzen for their contribution to the design of the study, Kathy Lawrence for the data management, the sisters and the fieldworkers for their help in gathering data, and the people of Ravensmead and Uitsig for their participation.

**Authors’ affiliations**

S den Boon, S W P van Lill, N Beyers, Centre for TB Research and Education, Department of Paediatrics and Child Health, Stellenbosch University, P O Box 19063, 7505 Tygerberg, Cape Town, South Africa

S den Boon, M W Borgdorff, Academic Medical Centre, Amsterdam, The Netherlands

M W Borgdorff, S Verver, KNCV Tuberculosis Foundation, The Hague, The Netherlands

E D Bateman, Division of Pulmonology, Department of Medicine, University of Cape Town, Cape Town, South Africa

C J Lombard, Biostatistics Unit, Medical Research Council, Cape Town, South Africa

D A Enarson, International Union Against Tuberculosis and Lung Diseases, Paris, France

This study was funded by Stellenbosch University through funding from the South African Department of Trade and Industry (THRIP fund) and the Glaxo Smith Kline Action TB Programme, and the University of Cape Town Lung Institute. MWB and SV were supported by Areas Global TB Vaccine Foundation. None of the funding sources had any role in the study design; the collection, analyses, and interpretation of data; in the writing of the report; or in the decision to submit the paper for publication.

NB, EB, Svl, DE, and MB were involved in the study design and writing of the manuscript. SdB performed the statistical analysis and wrote the paper. Advice on statistics was given by CL, SV and MB. All authors participated in interpretation of the results. NB supervised the data collection and MB the statistical analyses.

**REFERENCES**


Association between smoking and tuberculosis infection: a population survey in a high tuberculosis incidence area

S den Boon, S W P van Lill, M W Borgdorff, S Verver, E D Bateman, C J Lombard, D A Enarson and N Beyers

Thorax 2005 60: 555-557
doi: 10.1136/thx.2004.030924

Updated information and services can be found at:
http://thorax.bmj.com/content/60/7/555

These include:

References
This article cites 14 articles, 2 of which you can access for free at:
http://thorax.bmj.com/content/60/7/555#BIBL

Email alerting service
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Topic Collections
Articles on similar topics can be found in the following collections

Health education (1223)
Smoking (1037)
Tobacco use (1039)

Notes

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/